skopische Physiographie" is contemplated by Mr. J. P. Iddings, of Washington. It is proposed to omit those parts which are not essential to the production of a good text-book, and to incorporate the remaining portions in one volume. As the labor involved in translating the work is very great, it may be some time before the English version is given to the public.

BOTANY.[1]

A Study of the Growing Parts of the Stem of Pinus strobus. THE WHITE PINE.[2]—Before beginning work on this special part of the subject a cursory examination was made of the tissues in general as compared with that of *Pinus sylvestris*, the so-called Scotch Pine. Roughly speaking, they are the same,—a central pith, a zone of xylem varying in width according to the number of years' growth, the phlœum, outer cortex, and the epidermal system. But by direct comparison the tissue of the White Pine is seen to be more dense than that of its foreign relative,—the cells having a smaller diameter and the resin passages being smaller and less numerous.

In *Pinus sylvestris* there are two rows of resin passages in each year's growth of the xylem, one comparatively near each margin of the zone, while in *Pinus strobus* there is but one row, which lies towards the outer part of the zone. Sometimes an extra passage is found lying deeper in the xylem. On the contrary, in the outer cortical tissue of *Pinus strobus* are two rows of resin passages, the inner row being much larger than the outer one, but both being quite large, while there is but one row found here in *Pinus sylvestris*.

Growing from the epidermis of the bud and young shoot of *Pinus strobus* are many glandular, often capitate, hairs, composed of but two or three somewhat elongated cells, filled with densely granular matter. These appear to be secretory hairs, producing the resin that is found in such abundance in the bud of the White Pine. They were not found in the Scotch Pine.

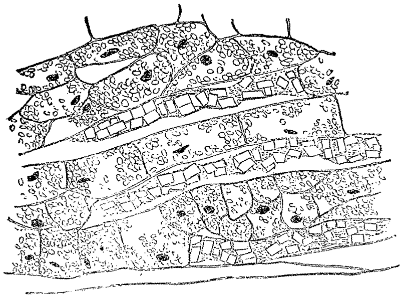
In the phlœum, in elongated cells which are distributed irregularly throughout this tissue, with the exception that they never occur within a zone of about eight cells from the xylem, occur large numbers of crystals of oxalate of lime. Fig. 1 of plate is a camera drawing of a longitudinal tangential section through the phlœum of a one-year-old stem, showing parts of five of these cells, three of which contain crystals. These crystals do not lie in the cell-wall, but are embedded in a substance which more or less completely fills the cell, offers great resistance to acids, is

[1] Edited by Prof. CHARLES E. BESSEY, Lincoln, Nebraska.

[2] Selected for publication from original work of students in the botanical laboratory of the University of Michigan, 1885–86, and communicated by Professor V. M. Spalding.

PLATE IX.

1.



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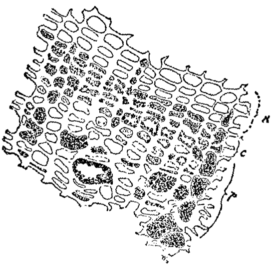

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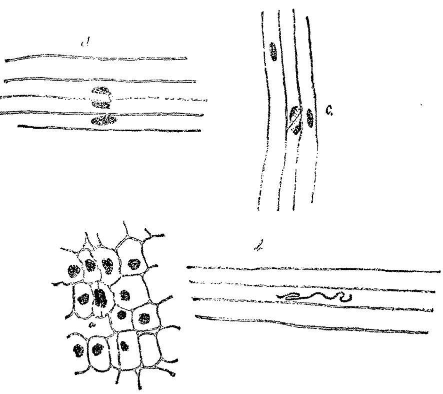

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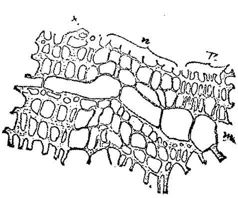

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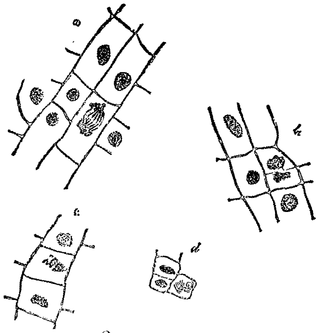

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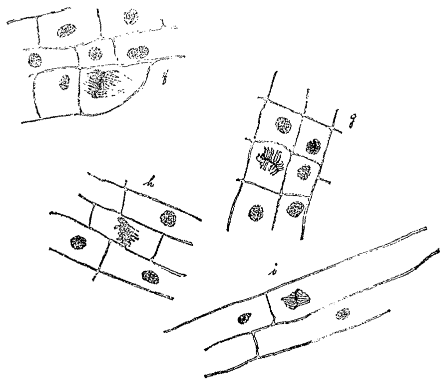

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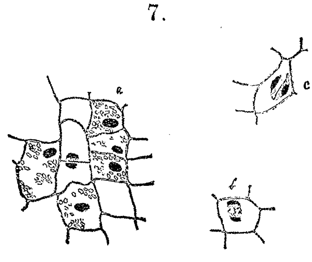

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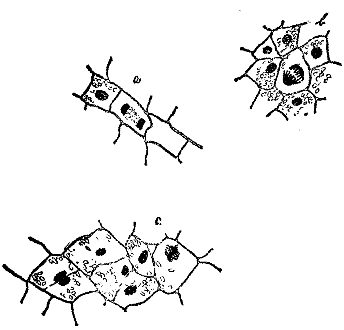

not affected by ether, and stains from yellowish brown to dark blue with Hanstein's aniline violet. The cells surrounding these contain much starch and protoplasm, with usually a nucleus.

Resin passages are also found in the phlœum and outer cortex, which do not run parallel to the long axis of the stem. Some were found running radially from towards the centre. At one end of some of these radially directed passages they bend at, or nearly at, a right angle, and pass up the stem. The great majority, however, run longitudinally through the stem.

Looking at the stem as a whole, at the centre is the pith or central cortex, composed of loose parenchymatous cells, then the protoxylem, composed of groups of scalariform and spiral vessels, which merge into the zone of xylem, composed of elongated ligneous cells, whose radial walls are thickly pitted. Outside of this is the cambium, or "growing part," a zone of cells with cellulose walls, definitely marked off from the xylem, but merging without any distinction into the zone of phlœum. In the stem cut in the winter, when growth is arrested, there is a zone varying from about three to five cells broad, in which the cell-walls stain somewhat more quickly and deeply with Schultze's solution than those of the surrounding tissue, and the cells of this zone are more densely filled with granular protoplasm. Fig. 2 is a camera drawing of a cross-section of a stem in which growth had not yet commenced: (*x*) a few cells of xylem, (*c*) the cambium zone and (*p*) the phlœum, (*m*) a medullary ray reaching only into the edge of the xylem.

Beyond the cambium is the zone of phlœum, composed largely of sieve-tubes, but containing the elements before described. Next is the outer cortical zone, with elements very similar to those of the pith, and outside this the epidermal system.

This much with the view of obtaining a better understanding of the position and of the elements in which growth takes place.

My method in the work was as follows: Stems from one to four years old, and buds, or young shoots, as the case might be, were taken from a thrifty growing tree at periods varying from four to ten days apart, and beginning before the commencement of growth in the spring. This material was preserved in alcohol and used as desired. Schultze's solution and Hanstein's aniline violet gave the best satisfaction as staining agents: Schultze's solution for differentiation of tissues, the aniline violet for staining nuclei. To clarify the sections, after cutting I placed them in sulphuric ether for some time, which removed the resinous substances, then, if staining with the violet, I removed them to a reduced solution of this, and after overstaining removed the excess with alcohol by placing the sections in it for a short time, and afterwards cleared with clove oil and mounted in dammar.

Taking the bud first, as it seems the most suitable place to start with, I found the growth for a period of a few weeks proceeding much more rapidly in the cortical and medullary tissue than in any other place. The first signs of growth appeared about April 20; and in the material cut May 6, the cells of these tissues were in their most active state of division, longitudinal sections showing large numbers of dividing nuclei. At this time the ground tissue composed the greater part of the stem, though the vascular system had increased considerably. Soon the growth in the cortical and medullary tissues almost entirely ceased. May 27, cell-division had so nearly ceased in these tissues that I could find no dividing nuclei, though I spent much time looking for them; and in the same material cell-division was taking place along the cambium line.

But growth does not entirely cease, at least in the outer cortex, for I found cell-division here in a three years' growth.

Fig. 3, *a*, is a camera drawing from near the epidermis of a three-year-old stem, showing a nucleus that has divided and the new cell-wall just formed. I think, in this tissue, growth continues by cell-division as long as the tree lives. Growth also takes place here by these cells becoming somewhat larger, and they often become elongated somewhat tangentially.

As to the length of life of these cells I can say but little. Many were found, even in the first year's growth, which were empty and dead; but in the same tissue taken from the body of a tree eight inches in diameter the great majority of the cells contained protoplasm and nuclei. I do not think the central cortical tissue lives very long, though I found some cells of a four years' growth containing protoplasm and starch.

The main growth of the stem is along the line of cells designated as the "cambium zone." On one side the cells that are here newly formed pass into the xylem, on the other into the phlœum. As each year's growth of xylem is much larger than that of the phlœum, many more cells must go to the formation of xylem than of phlœum.

To all appearances, when the stem is growing, the cambium zone is but one cell broad, as all nuclei that show signs of division in this tissue are found along a straight line in a longitudinal radial section.

Fig. 3, *c*, is a longitudinal section through a three-year-old stem, cut May 26, showing cell-division through the shorter diameter of a cambium-cell, thus showing that there must be some growth in length after the stem is three years old.

I found neither protoplasm nor nuclei in the xylem more than one year old, but in cells of the medullary rays passing through the zylem, and which were four years old, I found protoplasm and nuclei.

Many cells of the phlœum, in all specimens examined, were

apparently empty and lifeless, but the great majority contained nuclei. Some of these cells must have been quite old, as I examined some sections of phlœum from the body of a tree about eight inches in diameter.

In studying the structure of the nucleus and the process of cell-division, I had about equal success in the three above-mentioned tissues.

Fig. 4 is from a drawing of a cross-section of a young shoot cut April 26, showing a few cells of the xylem (*x*), the newly-formed tissue (*n*), some cells of the old phlœum (*p*), and a medullary ray (*m*). In this shoot a zone about seven cells broad had formed.

To obtain some idea of the rate of cell-division I made an estimate of the number of newly-formed cells produced by the cambium in a piece of a three-year-old stem one inch long, cut April 26, by counting the number of cells in the breadth of the zone, the number of cells around the stem, measuring the length of a number of cells, and taking the average. Also, in obtaining the number of cells around the stem, I took four sections from different stems, but all of about average size, and took the average. By this means I estimated the number of newly-formed cells, in such a piece of stem one inch long, April 26, to be 560,640. As April 17 there were no signs of growth, and as I could find but few nuclei and cells in the process of division in the material cut April 26, and from the great number of newly-formed cells, I conclude that the entire process of cell-division can last but a very short time,—perhaps two or three hours.

Fig. 5, *a*, *b*, *c*, *d*, and Fig. 6, *f*, *g*, and *h*, are camera drawings of some of the forms of the dividing nucleus found in the medullary rays along the line of the cambium. These are all from a four years' growth, cut May 6 and 26.

Fig. 6, *i*, and Fig. 3, *b*, *c*, *d*, represent some forms found in the cambium from material the same as the above. Fig. 7 represents cells from the inner cortex of a young shoot cut May 6, and Fig. 8, the same from the outer cortex.

Forms essentially like all these drawn were found in each of the three tissues, and from these we can trace the process of growth of cell-division in the pine.

First the nucleus in a state of repose, the nuclear filament folded so as to appear to be a densely granular ovoid mass. Fig. 3, *b*, shows one of these filaments lying in the cambium of a three years' stem, which was probably straightened by the razor in making the section. It demonstrates the composition of the nucleus. About the first change manifest in division is the segmentation of the nuclear filament, shown in Fig. 5, *c* and *d*. Then these segments double and arrange themselves in a radial manner around a common centre, as shown in somewhat varying stages in Fig. 8, *c*, and Fig. 6, *g* and *h*. Then the formation of

the nuclear threads running off from the ends of these segments to the poles of the nuclear spindle, as shown at Fig. 6, *f* and *i*.

These "conjunctive threads," as Fol calls them, arrange themselves in such a manner as to form a double hollow cone with a common base. The segments of the filament then pass out along the line of these threads and gather at the two poles of the spindle. Fig. 5, *a*, and Fig. 8, *b*, show early stages of this transformation, and Fig. 8, *a*, and Fig. 7, *b*, a little later. The new cell-wall or "nuclear plate" is then formed, as shown in Fig. 7, *c*, across these threads at right angles and about midway between the two masses of filaments, the parts of each of which have now united and form a rounded mass, in appearance like the mother-nucleus. The formation of the nuclear plate continues until it reaches across the cell from side to side and forms a complete cell-wall. All these sections are radial longitudinal ones.—*Elmer Sanford.*

ENTOMOLOGY.

Critical Remarks on the Literature of the Organ of Smell in Arthropods.—[The following abstract of the more important portions of Kraepelin's criticisms on the works of writers on the olfactory organs of arthropods, may prove not unwelcome to our entomologists, who may never be able to obtain Kraepelin's rather rare pamphlet. See pp. 889 and 973 of vol. xx.—*A. S. Packard.*]

My own observations on different groups of insects agree, in general, with those of Perris, Forel, and Hauser, without being in a position to confirm or deny the varying relations of the Hemiptera. That irritating odorous substances (chloroform, acetic acid) cause the limbs to move in sympathy with the stimulus, I have seen several times in Acanthosoma; still it may be a gustatory rather than olfactory stimulus.

As regards Crustacea, there are no observations or experiments (except on Asellus) on the conjectural seat of their olfactory organs. It should be here mentioned that Jourdain has described and Professor Dohrn, in Naples, has reported to me that the Brachyura by a remarkable movement of their inner antennæ, which are almost continually in convulsive movements, seem to support the opinion long entertained of the perception of odors by the antennæ.

As to spiders, it is not certainly known whether and to what extent they share in the sense of smell. Robineau-Desvoidy (1842) said that their sense of smell is very well developed and localized in the mandibles, but Perris placed them in the lowest rank of arthropods, though he remarks on "the sensibility of their palpi to smells."

Turning now from speculation and simple observation to exact anatomical and histological data, the nerve-end apparatus seems